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THE QUADRANT ELECTROMETER.

By JOHN MUNRO.

For the benefit of our students we give a full illustrated abstract of a paper recently read before the Society of Telegraph Engineers, by Mr. John Munro, and bearing this title. In subsequent numbers of the Student's Column various methods of testing with this instrument will be described.

Requirements of an Electrometer.—Without proper means of measurement no science can prosper and become applied, and as every electric phenomenon is primarily due to differences of the electric potentials established among matter, an electrometer, or instrument for measuring differences of potentials, is a primary necessary to the advance of our knowledge of electricity and our application of it to the Arts. Since the last century various rudimentary electrometers have been contrived for experimental purposes, but these have been more or less crude and imperfect. The modern electrometer, besides answering the uses of scientific research, should with advantage be fitted for the commoner work of telegraphy. It should be adapted to measure alike the agency of the thunderstorm, and secular variations in the electromotive force of the most constant galvanic element. Its degree of range and sensibility should therefore be great, and readily modified. The Thomson quadrant reflecting electrometer possesses these requirements to a hitherto unequalled extent, and for stationary employment far exceeds all others in utility.

Potential.—Difference of electric potential, or "electromotive force," is thus defined by Sir William Thomson:—"The amount of work required to move a unit of electricity against electric repulsion from any one position to any other position is equal to the excess of the electric potential of the second position above the electric potential of the first." Thus a difference of electric potential takes the form of mechanical work; and it follows also that a positively or negatively electrified body will experience a force tending to move it from a place of greater positive or negative potential to a place of less positive or negative potential. This is the principle of all electrometers. A light, easily movable conducting body, charged with electricity, is placed between two conducting systems, and the difference of electric potentials established between these latter is indicated by the motion of the former. The direction of motion denotes the *kind* of the difference, and the amount of the motion, determined by scale, measures the *amount* of the difference.

Electrometers Classified.—Sir William Thomson has divided electrometers into three classes:—(1), repulsion electrometers; (2), symmetrical electrometers; and (3), attracted disc electrometers. Beccaria's pair of diverging straws, Bennet's pair of diverging gold leaves, belong to the first of these classes; Bohnenberger's gold leaf and dry pile electrometer, and divided ring (including the quadrant) electrometers to the second; and Thomson's new absolute and portable electrometers to the third. The same philosopher further says, that "there are at present only two known species of the second class; but it (the second class) is intended to include all electrometers in which a symmetrical field of electric force is constituted by two symmetrical fixed conductors at different electric potentials, and in which the indication of the force is produced by means of an electrified body, movable, symmetrically, in either direction from a middle position in this field."

General Description of (2) *Electrometer.*—As a whole the instrument consists of a cylindrical Leyden jar of white flint glass with rounded bottom, its entire shape being like a conical bullet. This jar is supported upright in a strong brass frame of three legs; the mouth of the jar is closed by a plate of stout sheet brass, which is fastened to the brass framing, and can be lifted off at will. This plate of brass is called the "main cover," and all the interior works of the instrument are fixed to and supported by it. Part of the works, as the quadrants and the needle, are below this cover, and part, as the mirror, the point of suspension of the needle and the gauge (of which more hereafter), are contained in a lanthorn-shaped chamber of brass with a glass front, which stands upon, and rises several inches above, the main cover; while the "electrodes," or metallic rods, by which the quadrants communicate with the outer air, run through the front of the lanthorn and the cover, and rest their feet upon the top surfaces of the two front quadrants. A circular spirit-level is fixed to the main cover; and each corner of a triangular base-plate, with which the three legs of the frame are tied together, at the bottom, is fitted with a milled-headed screw as a foot, so that the whole instrument can be truly levelled.

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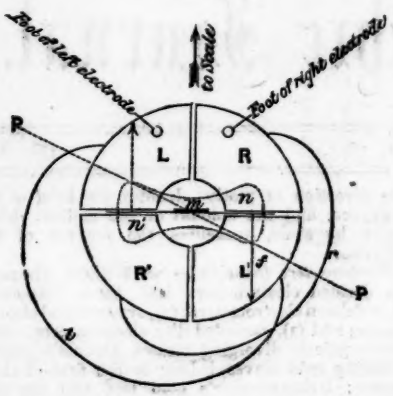
The Quadrants.—The "quadrants," which, together with the "needle," are shown in plan (L L', R R', Fig. 1), "consist of four quarters of a flat circular box of brass, with circular apertures in the centre of its top and bottom." Each is supported and insulated on a glass stem, which projects

FIG. 1.



downwards from the cover of the jar, and, as these stems are admitted a certain amount of play in radial slats, the quadrants can, at will, be caused to approach to or recede from each other in a symmetrical manner. Three of them can be directly shifted by hand. The fourth is moved by turning a micrometer screw, which gives the manipulator great command over its motion. The quadrants being thus movable can be brought geometrically symmetrical to each other, and yet be separated from each other, by air spaces, at a common or different distances variable at will within certain limits. The quadrants are *paired* by cross wires (*l r*) connecting those which point to each other, so as virtually to form two separate conductors out of the four. Each "electrode" makes good contact with the front quadrant of its corresponding *pair* by a broad silver foot, and, as it is essential that each *pair* of quadrants may be insulated from the rest of the electrometer, the electrodes are encased in vulcanite, where they pass through the cover of the jar of the lanthorn.

The Needle.—The "needle" (*n n*, Fig. 1) is a thin disc of aluminium, shaped like a double-canoe paddle. It is rigidly fixed to an axis of stiff platinum wire (*k*, Fig. 2), in a plane perpendicular to the wire. This, together with the needle, is suspended by means of a small cross-piece (*i*, Fig. 2) at its head from two brass pins (*c d*, Fig. 2), which project from a brass plate inside the lanthorn, by two single fibres of floss silk (*f g*, Fig. 2). These two fibres form the "bifilar suspension," which has superseded the single fibre and magnets of the original instruments. The object to be attained is, that the needle should of its own accord return to a zero position. In the earlier specimens of this electrometer this was done by a magnetic adjustment similar to that in the mirror galvanometer; but the bifilar suspension secures this in a more advantageous way.

The Suspension of Needle.—Just below the cross-piece the wire carries a light concave "mirror" of silvered glass (*m*, Fig. 1, and *h*, Fig. 2), firmly cemented to it. The wire, and the needle with the mirror rigidly attached, form the "movable conductor" of the electrometer. The fibres *f g* are fastened to the screws *c d*, and can be wound round them at will by turning these screws; thus each fibre can be lengthened or shortened: *a*, *b*, and *e* (Fig. 2) are also screws having drilled heads like

FIG. 2.

the screws *c d*, so that the same square-pointed key fits them all. By operating upon *a* and *b* the points of suspension *c* and *d* can be shifted in a plane normal to that of the diagram. The pin or screw *e* is conical, and by turning it the distance between the points *c* and *d* can be regulated.

Guard Tube.—The lateral deviation of the movable conducting system is presented by partially enclosing it in a brass "guard-tube," which freely admits of all necessary movements, but preserves it from being knocked about too much and damaged.

Leyden Jar.—The Leyden jar is coated externally with strips of tinfoil, but for the inner conductor, in addition to tinfoil, a quantity of very strong sulphuric acid is kept in the bottom of the jar. The main use, however, of this acid is to dry the air inside the instrument, and so preserve the insulation of the various internal parts.

Use of Jar.—The use of the jar itself is to preserve the movable conductor in an electrified state, and this is done by means of a line and plummet which hangs from the end of the movable conductor, and dips into the sulphuric acid. [This plummet, while it puts the needle at the same potential as the acid, also serves to steady the needle.] And in order that the electrification of the conductor shall be sensibly constant from day to day, it is necessary that the charge of the jar should be maintained the same. To make good, therefore, the small loss of charge which perpetually takes place, and cannot be entirely prevented, the instrument is fitted with a "replenisher."

(To be continued).

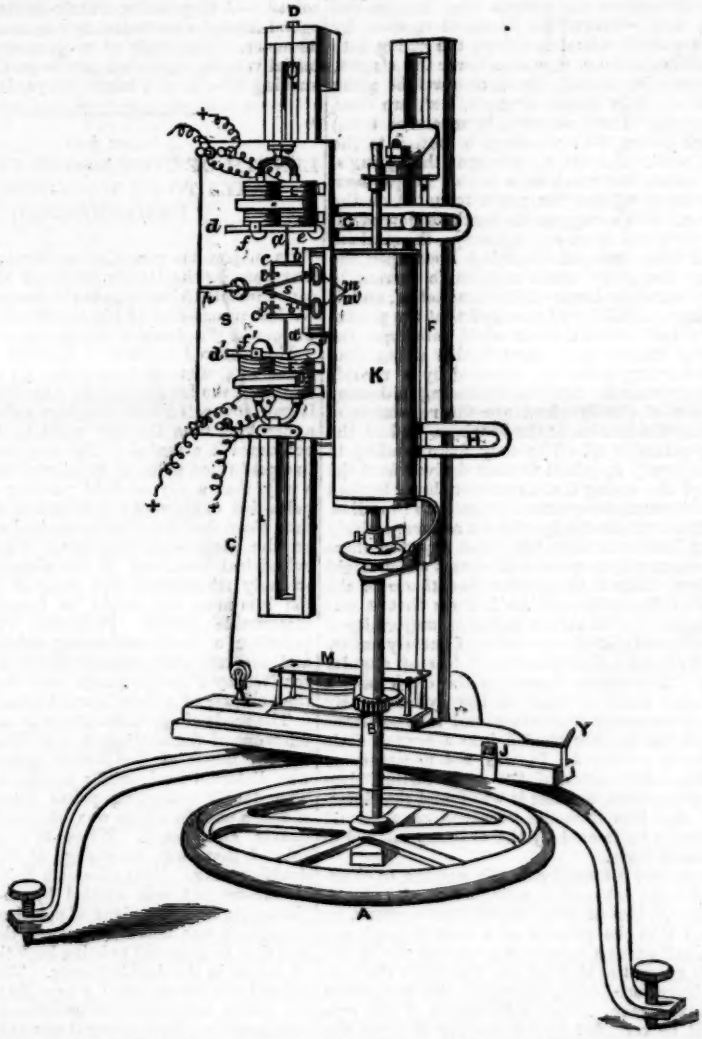
MESSRS. C. DE BERGUE and Co. have recently erected, at the Charlton Works of Messrs. Siemens, Brothers, eleven new wrought-iron cable tanks, and have made considerable additions to the height of several previously-existing tanks, intended to receive the cores under contract by Messrs. Siemens. The tanks are severally of 34 feet diameter and 42 feet length.

ELECTRIC CHRONOGRAPHS.

(Continued from page 327.)

THE instrument with which experiments have been most recently made, the chronograph of Prof. Bashforth,* next claims our attention. This chronograph, the author says, was designed with a view to secure the following conditions:—(1). The time to be measured by a clock *going uniformly*. (2). The instrument to be capable of measuring the times occupied by a cannon ball in passing over any number of *successive equal spaces*. (3). The instrument to be capable of measuring the *longest known time* of flight of shot or shell. (4). Every beat of the clock to be recorded by the *interruption* of the same galvanic current, and under precisely the same conditions, (5). The time of passing each screen to be recorded by the momentary *interruption* of a second galvanic current, and under precisely the *same conditions*. (6). Provision to be made for keeping all the strings or wires of the screens in a *uniform state of tension*.

FIG. 4.



It will be needless that we should enter upon the

* "A Mathematical Treatise on the Motion of Projectiles. Founded chiefly on the Results of Experiments made with the Author's Chronograph." By Francis Bashforth, B.D., Prof. of Applied Mathematics to the Advanced Class of Royal Artillery Officers, Woolwich, and late Fellow of St. John's College, Cambridge. London: Asher and Co. 1873.

description of the methods of fulfilling all these conditions; we at once will give Prof. Bashforth's description of his instrument. He says:—In contriving my instrument I at once abandoned all attempts to drive the cylinder at a known uniform angular velocity. Fig. 4 gives a general view of the instrument as constructed and used in experiment. A is a fly-wheel, mounted on a vertical axis. K is a cylinder, intended to be covered with paper prepared to receive the records made by the two markers, *m m'*. When the fly-wheel is spun by hand, the toothed wheel B allows the string C to unwind from the drum M, and so lower the stage S, which descends smoothly by its own weight along the slide L. Two electro-magnets, E E', are fixed to the stage S. These magnets, by means of arms, *a a'*, work levers, *b b'*, which give motion to the markers, *m m'*. A lever, *h*, acts upon the spring *s*, and so raises the markers *m m'*, or keeps them gently pressed against the paper mounted on the cylinder K, If we suppose the markers depressed, and the fly-wheel spun, *as a gyroscope*, the markers *m m'* will trace two parallel spiral lines upon the cylinder. But if we cause a galvanic current to circulate round the lower electro-magnet E', and if the galvanic circuit be so arranged that the pendulum of a half-second's clock shall *interrupt and restore* the current once every double swing, then we shall have upon the spiral traced by *m'* records made every second. The forces tending to destroy the motion of the fly-wheel are the resistance of the air and the friction at the bearings, and at the marking-points *m m'*. The only force tending to drive the heavy fly-wheel is that derived from the tension of the string C acting through the toothed wheel B, about three-quarters of an inch in radius. The cylinder K and the fly-wheel A are respectively 4 and 18 inches in diameter. The object of these arrangements was to remove all causes which might be likely to disturb the *perfect smoothness* of the rotation of the cylinder. As I knew that it was quite impossible to secure *sufficient uniformity* of angular velocity of the cylinder, I merely endeavoured to secure a *uniformity of loss* of angular velocity. The regular beating of the clock gave a diminishing scale of time on the cylinder. By means of necessary corrections and interpolations this scale was further divided into a correct scale of tenths of a second. It was not necessary to carry the subdivisions of the scale further than tenths of a second, because it was found that intervals of time less than the twentieth of a second could always be treated by the ordinary method of proportional parts.

Suppose now a second galvanic current to circulate about the other electro-magnet, E, and also to pass through two or more equidistant screens, so contrived that the passage of a shot through any screen shall cause a *momentary interruption* of the galvanic current at that screen, but allow the current to be restored again before the shot can arrive at the next screen. Each interruption of the current will be recorded by the marker *m* upon the rotating cylinder *k*. Afterwards the clock and screen records are measured off, starting from some line drawn on the surface of the cylinder parallel to its axis.

This form of chronograph is officially known as the clock-chronograph; but it is easily to be seen that the same instrument admits of arrangement as a gravity chronograph. In this case the stage S is rendered stationary, the lowering machinery M C D removed, and the slide L may be of wood. Only one electro-magnet, E, is necessary. A falling weight fires the gun, and directs the current to the electro-magnet. With these instruments, and by Bernoulli's analysis, Prof. Bashforth has succeeded in producing a series of very valuable tables, by which such problems as the following may be solved:—A 16-pounder muzzle-loading gun fires an ogival-headed shot 16 lbs. in weight and 3·54 inches diameter. The angle of projection being 2°, the initial velocity 1358 feet per second, required the striking velocity at a target 500 yards off.

ON THE

LENGTH OF TIME WHICH FLINT GLASS TAKES TO BE MAGNETISED AND DEMAGNETISED.

THIS subject has recently been investigated, for the first time, by the Italian Professor Villari, who has communicated his results to the *Instituto Lombardo*. (A full translation of his paper may be found in *Poggendorff's Annalen*, No. 7, 1873).

He procured a polished cylinder of dense flint glass, 10·5 m.m. in height and 63 m.m. diameter, and fixed the border of it in a brass ring, by which it was connected with the last axis of a rotatory apparatus; thus the disc could be made to rotate 200 times in a second. The disc was between the two perforated poles of an electro-magnet, in such a way that a ray of light passing through these poles fell exactly on a diameter of the disc. It is thus clear that if a Nicol-polarised ray were to fall on the glass disc, the latter would act like a cylindrical lens, and if the electro-magnet were strongly magnetised, the plane of polarisation of the luminous ray would be turned to a certain measurable extent. Professor Villari used as polariser a double-refracting achromatic prism; and the ray, after passage through the disc, was received by a double quartz, and then analysed by the analyser of a Soleil's saccharimeter.

The mode of operation was now as follows:—The telescope of the analyser was so directed as to give a clear image of the double quartz plate, which was distorted horizontally by the cylindrical lens. The doubly refracting prism being then turned round, a certain colour was obtained in the double quartz and noted. When the glass disc was rotated, there was no change of the colour of the double quartz. Next (the disc being at rest), the electro-magnet was excited by 10 or 15 carbon elements; and (the plane of polarisation being thus turned), it was noted how much the compensator had then to be moved to bring back the homogeneity of colour in the double quartz. Then the disc was rotated at a known rate; a new change appeared in the colour, which was also measured by moving the compensator. In this way it was shown, from many experiments, that the disc when not magnetised is quite neutral with regard to polarised light whether it is at rest or put in rapid motion; and, secondly, that the plane-rotating power observed in the fixed disc is reduced more than a half when the disc is rotated 140 times in a second, that is, that when the disc is quickly rotated, it is less polarised by

the action of the electro-magnet than when it is fixed, and naturally so, because the rotating disc remains too short a time with each of its diameters in the axial direction of the magnetising magnet to receive all the magnetism it is capable of receiving when allowed a longer time.

Professor Villari describes a series of researches springing out of those described. The general results obtained are thus summed up:—

1. The action of rapid rotation of a flint glass disc between the poles of an electro-magnet has the effect of lessening the magnetism produced in the disc.

2. This diminution is greater the more rapid the rotation.

3. In order to make a weak diamagnetism disappear, a less rapid rotation is required than to destroy a stronger.

4. In order to call forth such a diamagnetic intensity in flint glass as can be observed through the rotation of the plane of polarisation, a space of time not less than 0·001244″ is necessary.

5. The time is not always the same, and it decreases with the increase of the magnetising force. Hence the diamagnetic motions in flint glass are the more rapid the greater the demagnetising force.

6. In order to produce in flint glass the whole diamagnetism which it is capable of receiving under the action of a strong electro-magnet, a time not less than 0·00241″ is necessary, this being nearly three times as much as is required for the first symptoms of diamagnetism to show themselves.

7. The diamagnetism in flint glass, under the conditions of experiment described, continues for a space of time which is less than 18 hundred-thousandths of a second.

THE SELECTION AND NOMENCLATURE OF DYNAMICAL AND ELECTRICAL UNITS.*

We consider that the most urgent portion of the task entrusted to us is that which concerns the selection and nomenclature of units of force and energy; and under this head we are prepared to offer a definite recommendation.

A more extensive and difficult part of our duty is the selection and nomenclature of electrical and magnetic units. Under this head we are prepared with a definite recommendation as regards selection, but with only an interim recommendation as regards nomenclature.

Up to the present time it has been necessary for every person who wishes to specify a magnitude in what is called "absolute" measure, to mention the three fundamental units of mass, length, and time, which he has chosen as the basis of his system. This necessity will be obviated, if one definite selection of three fundamental units be made once for all, and accepted by the general consent of scientific men. We are strongly of opinion that such a selection ought at once to be made, and to be so made that there will be no subsequent necessity for amending it.

We think that, in the selection of each kind of derived unit, all arbitrary multiplications and divisions by powers of ten, or other factors, must be rigorously avoided, and the whole system of fundamental units of force, work, electro-static, and electro-magnetic elements, must be fixed at one common level—that level, namely, which is determined by direct derivation from the three fundamental units once for all selected.

The carrying out of this resolution involves the adoption of some units which are excessively large or excessively small in comparison with the magnitudes which occur in practice; but a remedy for this inconvenience is provided by a method of denoting decimal multiples and sub-multiples, which has already been extensively adopted, and which we desire to recommend for general use.

On the initial question of the particular units of mass, length, and time, to be recommended as the basis of the whole system, a protracted discussion has been carried on, the principal point discussed being the claims of the gramme, the *metre* and the second, as against the gramme, the *centimetre*, and the second; the former combination having an advantage as regards the simplicity of the name *metre*, while the latter combination has the advantage of making the unit of mass practically identical with the mass of unit volume of water; in other words, of making the value of the density of water practically equal to unity. We are now all but unanimous in regarding this latter element of simplicity as the more important of the two; and in support of this view we desire to quote the authority of Sir W. Thomson, who has for a long time insisted very strongly upon the necessity of employing units which conform to this condition.

We accordingly recommend the general adoption of the centimetre, the gramme, and the second, as the three fundamental units: and until such time as special names shall be appropriated to the units of electrical and magnetic magnitude hence derived, we recommend that they be distinguished from "absolute" units otherwise derived, by the letters "C. G. S." prefixed, these being the initial letters of the names of the three fundamental units.

Special names, if short and suitable, would, in the opinion of most of us, be better than the provisional designations "C. G. S. unit of . . . . . ." Several lists of names have already been suggested; and attentive consideration will be given to any further suggestions which we may receive from persons interested in electrical nomenclature.

The "ohm," as represented by the original standard coil, is approximately 10^9 C. G. S. units of resistance. The "volt" is approximately 10^8 C. G. S. units of electromotive force, and the "farad" is approximately $\frac{1}{10^9}$ of the C. G. S. unit of capacity.

For the expression of high decimal multiples and sub-multiples, we recommend the system introduced by Mr. G. J. Stoney—a system which has already been extensively employed for electrical purposes. It consists in denoting the exponent of the power of 10 which serves as multiplier, by an appended cardinal number if the exponent be positive, and by a prefixed ordinal number if the exponent be negative, Thus:—

10^9 grammes constitute a *gramme-nine*,

$\frac{1}{10^9}$ of a gramme constitutes a *ninth-gramme*,

* First Report of the British Association Committee on Units.

The earth's circumference is approximately four metre-sevens, or four centimetre-nines.

For multiplication or division by a million, the prefixes *mega** and *micro* may conveniently be employed, according to the present custom of electricians. Thus the *megohm* is a million ohms, and the *microfarad* is the millionth part of a farad. The prefix *mega* is equivalent to the affix *six*. The prefix *micro* is equivalent to the prefix *sixth*. The prefixes, *kilo*, *hecto*, *deca*, *deci*, *centi*, *milli* can also be employed in their usual senses before all new names of units.

As regards the name to be given to the C. G. S. unit of force, we recommend that it be a derivative of the Greek δυναμις. The form *dynamy* appears to be the most satisfactory to etymologists. *Dynam* is equally intelligible, but awkward in sound to English ears. The shorter form *dyne*, though not fashioned according to strict rules of etymology, will probably be generally preferred in this country. Bearing in mind that it is desirable to construct a system with a view to its becoming international, we think that the termination of the word should, for the present, be left an open question. But we earnestly request that, whichever form of the word be employed, its meaning be strictly limited to the unit of force of the C. G. S. system; that is to say, the force which, acting upon a gramme of matter for a second, generates a velocity of a centimetre per second.

The work done by this force, working through a centimetre, is the C. G. S. unit of work, and we propose to denote by it some derivative of the Greek ἔργον. The forms *ergon*, *ergal*, and *erg* have been suggested; but the second of these has been used in a different sense by Clausius. In this case also we propose for the present to leave the termination unsettled; and we request that the word *ergon* or *erg* be strictly limited to the C. G. S. unit of work, or what is, for purposes of measurement, equivalent to this, the C. G. S. unit of energy, energy being measured by the amount of work which it represents.

The C. G. S. unit of power is the power of doing work at the rate of one erg per second, and the power of an engine (under given conditions of working) can be specified in ergs per second.

For rough comparison with the vulgar (and variable) units based on terrestrial gravitation, the following statement will be useful:—

The weight of a gramme at any part of the earth's surface is about 980 dynes, or rather less than a kilodyne.

The weight of a kilogramme is rather less than a megadyne, being about 980,000 dynes.

Conversely, the dyne is about 1·02 times the weight of a milligramme at any part of the earth's surface, and the megadyne is about 1·02 times the weight of a kilogramme.

The kilogram-metre is rather less than the erg-eight, being about 98 million ergs.

The gramme-centimetre is rather less than the kilerg, being about 980 ergs.

For exact comparison, the value of g (the acceleration of a body falling *in vacuo*) at the station considered, must of course be known. In the above comparisons, it is taken as 980 C. G. S. units of acceleration.

* Before a vowel, either "meg" or "megal" (as euphony may ggest), may be employed instead of "mega."

One horse-power is about three quarters of an erg-ten per second. More nearly, it is 7·46 erg-nines per second, and one *force de cheval* is 7·36 erg-nines per second.

The mechanical equivalent of one gramme-degree centigrade) of heat is 41·6 megalergs, or 41,600,000 ergs.

MATHEMATICS
FOR
NON-MATHEMATICIANS.

By W. PAGET HIGGS, LL.D., D.Sc.

Division I.—The Algebra of Constant Quantities.

(Continued from Vol. I., p. 329.)

Continued Proportion, the Series, and the Summation of the Series.

Hitherto we have dealt with only *four* proportional quantities; but the principle of proportion can be extended to more than four (indeed to any number of) quantities. Thus we may have the following *arithmetical* proportion—

2, 4, 6, 8, 10, 12, 14, &c.,

in which the *difference* is 2; or we may have the following *geometrical* proportion—

2, 4, 8, 16, 32, 64, 128, &c.,

in which 2 is the *common ratio*.

Such a proportion, whether arithmetical or geometrical, is said to be *continued*. In fact, such a continued proportion forms an arithmetical or geometrical progression or *series*. Upon an earlier page (see page 264, vol. i.), will be found the algebraic representation of these series.

The previous study of the principles governing the relation of four proportional quantities will render much more easy our comprehension of the laws of the series, somewhat difficult to understand. We have learned that, in an arithmetical proportion, the sum of the extremes is equal to the sum of the means. This principle, widened out, also applies to a continued proportion or series. Let us take, in illustration, the seven terms of the arithmetical series given above—

2, 4. 6, 8, 10, 12, 14,

and represent the terms by the following letters—

a b c d e f g.

b and f, or 4 and 12; c and e, or 6 and 10; a and g, or 2 and 14; these will now be "similar" terms (see foot-note, p. 330), because the members of each set are equally distant from the beginning or from the end of the series. The sum of $b+f$, or $4+12$, is equal to the sum of $c+e$ or of $a+g$. Whence the rule: *In any arithmetical series, or continued proportion, the sum of any two "similar" terms is equal to the sum of any other two "similar" terms.*

When the number of terms is odd, there will be a middle term; twice this middle term (as above, $2d$), will be equal to the sum of any two similar terms of the series. This principle will guide us to a simple rule for finding the *sum* of *any* number of terms of an arithmetical series. We have seen that $b+f$, $c+e$, and $a+g$ are equal, and that d, the middle term, is equal to half the sum of any two similar terms, whence we can at once perceive that the sum of the terms, or $(a+g)+(b+f)+(c+e)+d$, is equal to $3\frac{1}{2}$ times $(a+g)$, or $3\frac{1}{2}$ times the sum of the extremes, or first and last terms. There are 7 terms; $3\frac{1}{2}$ equal to $\frac{7}{2}$, or half the number of

terms. We have then the rule: *To sum any number of terms of an arithmetical series, multiply the sum of the first and last terms (or the sum of any two "similar" terms) by half the number of terms.*

If the example selected for illustration had contained an even number of terms, say of 6 terms, as a, b, c, d, e, f, we should have had $a+f=b+e=c+d$, and we perceive that the sum of the series is three times $a+f$, or, as before, the sum of two similar terms multiplied by half the number of terms.

In a former page, the following formula has been given to find the last term (l) where that term is not stated. The formula is—

$$l=a+(n-1)d,$$

where l is the last term, a the first term, n the number of terms, and d the common difference. This formula, translated into words (it supposes the first term given, and also the common difference and number of terms of the continued proportion), tells us "that the last term may be found by adding to the first term (a) the common difference (d), multiplied by one less than the number of terms ($n-1$). Professor De Morgan gives the reason of this process in these words 'the passage from the first to the nth term is made by $n-1$ steps, at each of which the common difference is added.'"

The remaining problem is to find the common difference when the sum, the number of terms, and the first term of an arithmetical series, are given. To obtain a solution, we must first find the last term. This we get from the knowledge that the sum is the result of multiplying the sum of the first and last terms by half the number of terms; consequently the sum *divided* by half the number of terms will give a quotient which minus the first term is equal to the last term of the series; or—

$$l=\frac{s}{\frac{n}{2}}-a.$$

Now we have to pass from a, the first term, to l, the last term, by $n-1$ equal steps (the first step having been made at the first term, and n being the number of terms). Therefore the common difference—

$$d=\frac{l-a}{n-1},$$

or the ratio of the last term minus the first term to the number of terms less one. For example: Let the first term of an arithmetical progression be 3, the number of terms 50, and the sum 2600, to find the last term and the common difference.

The sum 2600 divided by half the number of terms $\left(\frac{50}{2}=\right)$ 25 is equal to 104, and this less the first term (3)=101, the last term. The last term minus the first term ($101-3=98$), divided by the number of terms less one ($50-1=2$), the common difference. The series is, therefore—

3, 5, 7, 9, 11, ... 101.

Similar short rules and simple reasons may be found for the processes of geometrical progression, or, in mathematical language, for the summation of the geometrical series.

If r be the common ratio, the geometrical series may be represented by the general algebraic formula—

$$a,\ ar,\ (ar)r,\ (ar\cdot r)r,\ \&c., \text{ or}$$
$$a,\ ar,\ ar^2,\ ar^3,\ \&c.$$

If, as in the example before given, $r=2$, and a the first term is 2, we have—

2, 4, 8, 16, 32, &c.

The rule quoted with regard to the *sum* of similar terms of *arithmetical* series, will of course hold good with a *geometrical* series if for the word *sum* we substitute *product*. The *product* of any two "similar" terms of a geometrical series is equal to the *product* of any other two "similar" terms of the same series. If the number of terms be *odd*, the *product* of any two "similar" terms will be equal to the *square of the middle term* (an expansion of the principle with which we became acquainted when considering the proportion of only four quantities).

When it is considered that the nth term of a geometrical series is nothing more than the multiplication of the first term by the common ratio raised to the $(n-1)$th power, it is easily seen that—

$$l=ar^{n-1};$$

and that it is necessary only to know the first term and common ratio to write down the succeeding terms to any number.

To learn how to sum any number of terms of a continued geometrical proportion, we must look again at the series $a,\ ar,\ ar^2,\ ar^3$. The sum of this, or $a+ar+ar^2+ar^3$ is evidently equal to $a(1+r+r^2+r^3)$; and this again is equal to—

$$a\times\frac{r^4-1}{r-1}=\frac{ar^4-a}{r-1},\quad (1)^*$$

when r is greater than 1; or equal to—

$$a\times\frac{1-r^4}{1-r}=\frac{a-ar^4}{1-r},$$

when r is less than 1.

From equation (1) we obtain the following general expression for the sum of the series, that is—

$$S=\frac{ar^n-a}{r-1}.$$

Again, since $l=ar^{n-1}$, we have $lr=ar^n$, and as we may substitute equivalent values in any equation, the following expression is obtained from that first given—

$$S=\frac{rl-a}{r-1}.$$

This, in words, means that to sum the series, the last term is to be multiplied by the common ratio less the first term; the result to be divided by the ratio less 1.

When r is less than 1, or is fractional, we have, according to the preceding formulæ—

$$S=\frac{a-rl}{1-r},\text{ or }=\frac{a-ar^n}{1-r}.$$

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* That $\frac{r^{(n+1)}-1}{r-1}=1+r\ldots+r^n$ is capable of proof by the following reasoning. For example, take—

$$\frac{r^3-1}{r-1}=1+r+r^2.\quad r^3-1=r^3-r^2+r^2-r+r-1,$$

since when we subtract r or its power, we subsequently add r or the the same power. r^3-r^2 is obviously equal to $r^2(r-1)$, and r^2-r is equal $r(r-1)$, whence $r^3-r^2+r^2-r+r-1=r^2(r-1)+r(r-1)+r-1$. Again, $r^2(r-1)+r(r-1)+r-1$ is r^2+r+1 taken $r-1$ times. In the second case, where r is less than unity, $1+r+r^2$ multiplied by $1-r$ is equal to $1-r+r(1-r)+r^2(1-r)$, and this equals—

$$1-r+r-r^2+r^2-r^3,$$

which again is equal to $1-r^3$. As $1-r^3$ is obtained by multiplying $1+r+r^2$ by $1-r$, so dividing $1-r^3$ by $1-r$ must yield the quotient, $1+r+r^2$. r^3 is a term higher $(n+1)$ than r^2; hence the rule:—"To find the sum of n terms of the series, $1+r+r^2+$ &c., divide the difference of 1 and the $(n+1)$th term by the difference between 1 and r."

In the latter case, the series is a decreasing one, and its terms continually approach 0 in value. Could the series be continued to *infinity*, we should undoubtedly arrive at the value of 0; that is, the last term (l) would be $=0$. The above equation therefore becomes (since multiplying by 0 gives 0)—

$$\Sigma^* = \frac{a}{1-r},$$

the sum of an infinite series, or when $n=\infty$.†

Examples.

Of increasing geometrical progression.—First term $=1$; ratio$=2$. Required the tenth term and the sum.—Answer: $l = ar^{n-1} = 1\times 2^9 = 512$, the 10th term. $S = \frac{rl-a}{r-1} = \frac{1024-1}{1} = 1023$, the sum.

Of decreasing series.—Sum the series $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}$, &c., to seven terms (1), and also to infinity (2).—Answer: (1). $r=\frac{1}{2}$, $n=7$, $l = ar^{n-1} = (\frac{1}{2})^6 = \frac{1}{64}$. $S = \frac{a-lr}{1-r} = \frac{1-\frac{1}{128}}{1-\frac{1}{2}} = \frac{\frac{127}{128}}{\frac{1}{2}} = \frac{127}{128}\times 2 = 1\frac{63}{64}$, the sum of seven terms. Answer (2)—

$$\Sigma = \frac{a}{1-r} = \frac{1}{1-\frac{1}{2}} = 2, \text{ the sum to infinity.}$$

Find the vulgar fraction equivalent to the circulating decimal, ·363636.—(Answer). This decimal expressed as a series is $\frac{36}{100}+\frac{36}{10000}+\frac{36}{1000000}+$ &c., the first term being $\frac{36}{100}$ and the ratio $=\frac{1}{100}$. Therefore, $\Sigma = \frac{a}{1-r} = \frac{\frac{36}{100}}{\frac{99}{100}} = \frac{4}{11}$.

Geometrical Means.

Professor Young, treating this point very simply, says, "When the leading term and any remote term are given, we may always find the intervening terms, and thus fill up the gap; for instance, if a and ar^4 be given, to find the *three* intervening terms we should divide ar^4 by a; and knowing—from the fact that there are *five* terms altogether—that the quotient would be the *fourth* power of the ratio, we should obtain the ratio itself by taking the fourth root of that quotient: by help of the ratio, the wanting terms may be easily supplied, as noticed above. These intervening terms are called *geometrical means* between the given extremes; if only *one* mean is to be inserted between two extremes, it is found by taking the square root of the product of the extremes. Suppose, for example, it were required to find a geometrical mean between 2 and 8: then, since the square root of 8×2, or 16, is 4, we know the mean to be this number; the progression being 2, 4, 8: if the proposed extremes had been -2, -8, we should have taken the *minus* root of 16, and have written the progression thus, -2, -4, -8: nevertheless, whether the given extremes be both *plus* or both *minus*, the square root of their product with *either* sign may be truly regarded as a *mean*, for the following are geometrical progressions, as well as those above, 2, -4, 8; -2, 4, -8; the common ratio *here* being -2; in the sets above it was 2. Again, suppose we had to insert *two* geometrical means between 3 and 81; then, as there are *four* terms altogether, the exponent $n-1$ above, is here 3, $\therefore 81\div 3 = 27 = r^3 \therefore r = 3$. Hence the progression is 3, 9, 27, 81; the required *means* being 9 and 27."

* Σ (the Greek capital *sigma*) is generally employed to represent the sum of an infinite series.

† The character ∞ is mathematically employed to represent infinity.

Errata (p. 331):—

For $\frac{1}{60}\times\frac{1}{60} = \frac{2600}{1}$ read $\frac{1}{60}\times\frac{1}{60} = \frac{1}{3600}$.

For $\left(\frac{v}{\bar{v}}\right)^x = \frac{r}{\bar{R}}$ read $\left(\frac{v}{\bar{v}}\right)^x = \frac{r}{\bar{R}}$.

Students' Column.

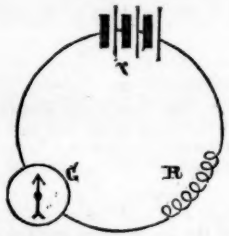
Resistances and their Measurement.—By H. R. Kempe.

I.—It is proposed, in the following series of papers, to show the different methods of measuring resistances, theoretically and practically,—to give a detailed description of the different forms of apparatus in general use for the measurement of resistances,—and to show the different methods of "joining up" for various tests as well as the proper way to manipulate the instruments.

We take it for granted that the student is familiar with the terms, *resistance, electromotive force*, &c., and understands their signification; therefore, without staying to discuss their meaning, we will at once proceed to examine the theory of the simplest method of measuring a resistance.

Suppose a battery of a resistance, r, a galvanometer of a resistance, G, and a wire of a resistance, R, be "joined up" in circuit, as shown in Fig. 1.

Fig. 1.



From Ohm's law, the strength of current, S, which will flow out of the battery and through the galvanometer will be—

$$S = \frac{E}{R+r+G}$$

E being the electromotive force of the battery.

The current, in flowing through the galvanometer, produces a deflection of its needle, which deflection will remain constant provided the electromotive force of the battery and also the resistances remain constant. If, now, we remove the wire, R, whose resistance we require to find, and replace it by another wire whose resistance is known, and which can be varied at pleasure by adjusting it so that the deflection of the galvanometer needle becomes the same as it was before the change of resistances was made, then this resistance gives the value of our unknown resistance, R.

Next, suppose the galvanometer to have its scale so graduated that the number of divisions on it will, by the deflection of the needle, accurately represent the comparative strengths (S) of currents

which may pass through the galvanometer. Let the battery, galvanometer, and resistance be joined up as at first, then as before—

$$S = \frac{E}{R+r+G}; \text{ or } E = S(R+r+G).$$

Now remove R, and insert any other known resistance, ρ, in its place. Calling, then, the new strength of current S_1—

$$S_1 = \frac{E}{\rho+r+G}; \text{ or } E = S_1(\rho+r+G).$$

Combining these two equations—

(1.) $S(R+r+G) = S_1(\rho+r+G)$,

from which—

(2.) $$R = \frac{S_1}{S}(\rho+r+G) - (r+G).$$

Now, as the deflections of the galvanometer needle are directly as the strengths of current which produce them, we may. instead of S and S_1, write in our formulæ the deflections of the galvanometer needle which those strengths produce. Calling, then, a° the deflection with the strength S, and $a_1{}^\circ$ with the strength S_1, our formula (2) becomes—

$$R = \frac{a_1{}^\circ}{a^\circ}(\rho+r+G) - (r+G).$$

In order to find R, it is necessary to know G, which is usually marked on the galvanometer itself by the manufacturer. r also must be known; but as it is difficult to determine its value accurately, it is always best to use a battery whose resistance is very small in comparison with the other resistances in the circuit, and which may consequently be neglected, in which case we may write our formula—

(3.) $$R = \frac{a_1{}^\circ}{a^\circ}(\rho+G) - G.$$

Having then obtained a° with R and $a_1{}^\circ$ with ρ, we can find the value of R. For example—

With a galvanometer whose resistance was 100 ohms, and a battery whose resistance might be neglected, we obtained with a resistance R a deflection (a°) of 20°, and with a resistance (ρ) of 200 ohms a deflection ($a_1{}^\circ$) of 30°, to determine the unknown resistance, R—

$$R = \frac{30}{20}(200+100) - 100 = 350 \text{ ohms.}$$

Next, suppose it is required to find the resistance of a galvanometer. From equation (1), putting $r=0$, we get that—

(4). $$G = \frac{Ra^\circ - \rho a_1{}^\circ}{a_1{}^\circ - a^\circ}$$

If, then, with a known resistance R we obtain a°, and with a known resistance ρ we obtain $a^\circ{}_1$, we can determine G. For example—

With a galvanometer (G) and a battery whose resistance may be neglected, we obtained with a resistance (R) of 200 ohms a deflection (a°) of 20°, and with a resistance (ρ) of 350 ohms a deflection ($a_1{}^\circ$) of 30°, to determine the resistance of the galvanometer—

$$G = \frac{350\times20 - 200\times30}{30-20} = 100 \text{ ohms.}$$

Lastly, when the resistance of our battery is considerable, and it is required to find its value, we get from equation (1)—

(5). $$r = \frac{a^\circ R - a_1{}^\circ \rho}{a_1{}^\circ - a^\circ} - G.$$

For example—

With a galvanometer of a resistance (G) of 100 ohms, and a battery (r), we obtained with a resistance (R) in circuit of 300 ohms, a deflection (a°) of 30°, and with a resistance (ρ) in circuit of 150 ohms, a deflection ($a_1{}^\circ$) of 40°, to find the resistance of the battery—

$$r = \frac{30\times300 - 40\times150}{40-30} - 100 = 200 \text{ ohms.}$$

The formula may be considerably simplified if we so adjust our resistances that one deflection becomes half the other, or, in other words, if we make $a_1{}^\circ = 2a^\circ$. Formula (3) for determining any resistance then becomes—

$$R = 2\rho + G.$$

Formula (4) for determining the resistance of a galvanometer—

$$G = R - 2\rho,$$

and formula (5) for determining the resistance of a battery—

$$r = R - (2\rho + G).$$

R being in all cases the resistance which gives the small deflection and ρ the smaller resistance which doubles it.

(To be continued).

PAPERS FOR JUNIOR STUDENTS.

Laws or Concise Definitions relating to Electro-magnetic and Magneto-electric Induction.

Edlund has shown that, in a closed secondary circuit, the induced current is proportional to the strength of current in the primary circuit.

Lenz has demonstrated the following:—The maximum of the induced current is proportional to the strength of the inducing magnet.

The electro-motive force which a magnet induces in a helix (spiral coil) of wire is, all other things remaining the same, proportional to the number of turns (convolutions) of the wire.

The greater the number of turns that can be wound near the magnetic core, the less number of turns will be required to obtain the greatest induced current.

The currents induced in the different coils of the wire, on any bobbin, are inversely proportional to their diameters.

The electro-motive force (*not* the current) induced by a magnet in a coil of given number of terms is the same, whatever may be the thickness or conductivity of the wire. The *current*-strength in coils of given number of turns is proportional to the conducting power of the wire.

The electro-motive force (*not* current strength) induced by a magnet in a coil of wire is equal, and independent of the radius of the coil.

The Extra Current.

If upon a single bobbin a long length of wire is coiled, one end of the coil being connected to a battery, there will appear upon closing the circuit (with the other end of the wire) a more or less brilliant spark, according to the number of turns of the coil, and to the strength of the battery. Upon breaking or opening the circuit a much more brilliant spark (and a more severe shock) will be observed than upon closing. Faraday referred this phenomenon, known as the *extra current*, to the induction of the turns of the coil of wire upon themselves. The reader will perceive that there is

reason for supposing one turn of the coil to act inductively upon the next, or even one portion of each turn upon another portion of the same turn. It will be seen that, in accordance with the general law of induction, every turn acting upon the next induces in that second turn a current in the opposite direction to the primary turn; this inverse current is opposed to the current entering the coil upon closing the circuit—hence the spark is less—and is in the same direction as the primary current when the circuit is opened—hence the spark is greater.

The extra current on closing is termed the *inverse extra current;* that on opening, the *direct extra current.*

To Edlund is due the determination of the laws of the extra current. They are:—

The electro-motive force of the extra current is proportional to the intensity of the primary current.

The intensities of the primary currents being equal, the extra currents on opening or closing the circuit have the same electro-motive force (but the current-strengths are unequal, as explained).

The direct extra current will give violent shocks, decompose water, magnetise steel needles, and has been used by Dr. Siemens to obtain the electric light for beacons, one of the ends of the circuit being in this case a dish of mercury. The extra-current will melt platinum, and this is one of the causes of the frequent failure of electric engines and clocks—for the spark being neither more nor less than a minute fragment of the metal in a state of incandescence, the contact-points are soon eaten away, or covered with a non-conducting film of oxide (burnt metal).

Prof. Abeid has found the intensity of the extra current to be about 0·72 of the principal current.

As with induction coils, the induced extra current acquires greater intensity when the wire surrounds a core of soft-iron, or, in other words, forms an electro-magnet. The cause of this has been explained by Faraday in the following words:—"If inside the spiral there is an iron bar, when on opening the circuit the principal current disappears, the magnetism which it evokes in the bar disappears too; but the disappearance of this magnetism acts like the disappearance of the electric current, the disappearing magnetism induces a current in the same direction as the disappearing principal current, the effect of which is thus heightened."

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The second meeting of the present session of this Society took place on Wednesday, the 26th ult.

The chair was taken by Mr. Cromwell Varley.

The Secretary read a short communication which had been sent by Mr. Neilson, of the Norwegian Telegraphs, with a specimen of three twisted No. 11 wires which had been melted by lightning. The wire was such as was used in some exposed situations in Norway. The writer had thought it to be of some interest to show this effect of lightning, as it had been stated in the Society's journal that No. 8 wire had never been melted by lightning when used as the earth wire.

The Chairman said that the specimen showed that the three wires had been fused together into one mass for a distance of about ½-inch at the part where they had been struck.

Mr. W. H. Preece said that the statement which Mr. Neilson had referred to was made by him (Mr. Preece). It was that No. 8 wire had never been fused when used as an earth wire; that statement was true, and the present instance was that of a line wire. There had been instances of No. 4 being fused when so used.

The Chairman said that he remembered one instance being reported by one of his superintendents, on the Chester and Holyhead Railway, of a piece of No. 8 line wire being fused near Conway. His reason for speaking about it was this. If a spark of lightning entered a wire, the action at the point of contact between the spark and the wire was very much greater in its heat-producing power than throughout the rest of the circuit. A small wire would suffice to carry through it a charge which, striking from that wire into a larger wire, would fuse the larger wire. It was very well known to those who used the voltaic battery, that if they took the two wires in their hands, and then placed the arc between them, the two ends would immediately get red hot, even in the case of a very thick piece of wire, though a very small wire was sufficient to carry the charge through, provided that there was no break. The fact that a wire had been fused did not show that it would not be strong enough to carry off the charge when struck at the end. Mr. Preece was quite right in stating that no earth wire had ever been known to be fused by a flash of lightning. All that could be fused would just be the tip where the spark would enter it.

A paper on "*Underground Telegraphs*" was read by Mr. G. E. Preece. Although the title of the paper was general, the author purposed to consider only one especial underground work carried out under different circumstances, namely, the system of underground wires along the main road, between Manchester and Liverpool, consisting of 14 wires for a length of 36 miles. All the previous underground works in England start from about the year 1853, and they consisted generally of the same form, the majority being laid by Mr. Henley, on his own plan. The Manchester and London wires for the Magnetic Company may be taken as a specimen of the whole. A second form was that carried out by the Electric Telegraph Company, in 1853, in laying down their express wires from London to Manchester and Liverpool. A third form may be represented by the underground wires laid by Mr. West, in the Isle of Wight, in 1856-57. The system adopted in the express wires was on the pattern of all our street works, and consisted of placing iron and earthenware pipes underground, and subsequently drawing loose cables in. The cables were taped, tarred, and sanded, and were in quarter mile lengths. The failure of that work came about very soon. The Magnetic Company's London and Manchester underground wires were laid in 1853. The work consisted of a cable of ten wires laid in grooved boarding. The wires were of No. 16 copper wire insulated with gutta-percha to gauge No. 3. The ten wires were placed parallel to each other in two rows, and served over with two servings of jute and Stockholm tar. Tests were taken both for continuity and insulation. A great number of faults were found. The generality were due to fixing the top of the boarding with nails, which were driven in carelessly. A few years after the completion of the work, the wires were continually failing, and ultimately the line was tested in 5 mile sections, and any section found to be faulty was replaced by a line overhead. At length none of the original work was left. Among the causes of failure was the perishing of the gutta-percha through dryness, stagnant water, and leak from neighbouring gas pipes. The Isle of Wight line consisted of india-rubber covered wires put down without any protection. These wires were abandoned in a few years. The causes of failure in the express wires between London

and Manchester have been eradicated in the present work; and the main causes of failure in the British Company's road wires will, it is hoped, be also avoided. This is a question which time alone can solve. This is, the author believes, the first time any severe and searching system of testing has been adopted in any such work. The line selected for laying down a series of underground wires was from Liverpool to Manchester. The survey for the route was made by Lieutenant Ramsay, of the Royal Engineers, under whose charge also the pipes were laid. The new work commenced where the street work in Liverpool ceased, and proceeded along the main road in iron pipes for some distance,—thence to Warrington by earthenware pipes, and thence in a mixture of earthenware pipes and iron pipes to Manchester. About seven miles from Liverpool the ground generally lies very low, and that part of the country is celebrated for its rainfall. On a considerable proportion of the route the water lies in the pipes even in summer. A more favourable situation for gutta-percha covered wires can not well be imagined. The various forms of cables hitherto used for underground work have differed in the size of the wires, but very little in their construction. Of the previous cables there may be said to be two forms, the general form being the straight wire cables consisting of a number of single wires covered with tarred tapes and bound together, forming a "cable" so called. The second, the form used by Mr. Henley in the works carried out by him, consisted of a number of plain gutta-percha covered wires laid parallel to each other, and being of the same length, and served over with tarred tape or some other preparation. The cables used in the present work were made by the Gutta-Percha Company, and were entirely different in their construction. They were of the true cable pattern. The core itself consisted of gutta-percha wire No. 7 gauge; copper wire No. 18 gauge, 39 lbs. to the mile; gutta-percha 46 lbs. per mile. It was manufactured in the ordinary way, being covered with two coats of compound, alternating with two coats of gutta-percha wrapping. The total weight was 85 lbs. per statute mile. The core, as it was manufactured, was cut off into special lengths as the cable required. The wires so cut off were wound on bobbins. The cables which were made up were subsequently passed through a bath of cold Stockholm tar in which was a quantity of fine cork-dust, to give the tar more solidity. After receiving this tar, the cable received two servings of tarred tape laid on in opposite directions. The tape was specially manufactured for the purpose. The cables, when ready for drawing in, were placed upon drums revolving on a stout frame, and at a convenient distance from the mouth of the pipe to avoid friction against the various points. Close to the mouth of the pipe was placed a wooden roller so as to prevent any friction against the edges of the pipe. After the cables had been drawn, and the wires numbered, the several ends were opened out, cleaned, and properly prepared for the jointers, who followed on as soon as they had completed the preceding set of joints. Each jointer had an assistant. The men employed at this work were more intelligent than the ordinary labourers. It was necessary that, as the work extended over open roads, a travelling testing-van should be constructed for the purpose not only of carrying the instruments and battery, but of affording accommodation for more than one person, and, indeed, acting as an office and travelling-carriage. A van admirably adapted for this service was designed by the author, and used in the work. The electrical apparatus consisted of 100 No. 3 Leclanché cells specially mounted on well-insulated tops. As the tests of the cable were to be almost identical with the ordinary tests of the submarine cable, the insulation of batteries and instruments was carefully secured. It being necessary to test the various joints throughout the work, a special joint-prop, with ebonite feet, was made for the purpose of placing inside the joint-boxes. For carrying out the tests, it was necessary to "make earth" wherever the van stopped. For this purpose a copper plate was used for places where water was at hand; and a long iron tube pointed at the bottom end, and with a screw connection for the earth wire at the top. This was driven into the ground at the dampest places, and answered admirably. The proper method of testing the joints was a question of some difficulty. After a great deal of consideration, and the abandonment of several plans, the author succeeded in devising a system which, he believes, will be found the best for adoption in all future underground works. The cables were tested in sections, and, immediately afterwards, all the joints of that section. The peculiarity of this plan is in so dividing the cables into sections varying in length, and in so looping the wires at the two ends, that a continuous circuit is formed. Any wire, therefore, in a joint-box will at once present the two ends of this continuous circuit, and render any tests of whatever kind perfectly easy. Condemned joints were replaced, and, as a proof of the improved insulation obtained by cutting out the bad joints, a statement may be given of the insulation resistance of the loops of two sections before and after the joints were cut out. In one section, the mean insulation-resistance before the joints were cut out was 111; afterwards, 481. In the other section, the mean of the fourteen wires throughout the section was 110. After the condemned joints had been cut out and replaced by good joints, the mean grew to 480. After a section had been passed, it was perfectly joined on to the next, and so on; but no section was added until the previous one had been found to be still in good condition. Of the various operations connected with practical telegraphy, there is scarcely one so important, or requiring so much practice and experience, as the making of the joints in a gutta-percha covered wire; and this operation was the most difficult throughout the work. Joints had to be condemned wholesale. Of the causes tending to bad joints, one is dissimilarity in the materials employed. Another cause was physical unfitness on the part of the workman. A greasy sweat sometimes issues from the pores of the hand, and it is easy to see that, as the joint requires frequent handling, this fact will tend towards bad jointing. The inclemency of the weather will sometimes interfere with the operation. And, lastly, the absence of cleanliness is one of the most serious defects a jointer can possess, and one which, more than anything else, is the cause of bad joints. The faults which beginners usually exhibit are simply the result of a want of experience, and this want practice alone can meet.

The CHAIRMAN said that the paper was one which would be sure to elicit a warm discussion, but the remarks must necessarily be somewhat curtailed, as a special meeting for altering the rules of the society was to take place after the present proceedings. He then invited Mr. Graves to open the discussion, he having had a great deal of experience as to the causes of failure on the Great Northern and North Eastern lines.

Mr. GRAVES said that perhaps the causes of failure were, throughout, the same—simply the neglect of the conditions which Mr. Preece had stated to be essential to the manufacture of a good joint. The joints, some years ago, were made without the slightest consideration of the conditions that were necessary to produce anything like a perfect result. To begin with, attempts were made to unite thick pieces of gutta-percha, simply by bringing together two portions of the material, very often imperfectly heated, and in a different state of temperature in relation to each other, and also frequently consisting of different manufactures.

They had, in the instances to which the chairman had alluded, very many failures. Those failures arose partly, perhaps, from primary defects in the material, but certainly more frequently from the deficiency in the jointing. The jointing was carried out simply by the rule-of-thumb; no process of testing was applied; neither was anything like skilled supervision brought to bear. Certain men who were supposed to be experienced in the duty had the work entrusted to them. The two pieces of copper wire were scraped, but the scraping was by no means a perfect operation, and very often the surfaces were irregular and separated by dirt. Then the quantity wound together was indefinite, and frequently the layers of wrapping failed to adhere to one another. There was a total absence of care to prevent the entrance of dirt; there was no thought with reference to the effects which might be produced by moisture; neither was there any full or complete knowledge of the conditions of perfect jointing, or, in fact, any intention to think of the necessity of acquiring such knowledge. The result was that, though the outside of the joint was perfect, the joint rapidly deteriorated. No gutta-percha covered wire that was laid down more than ten years ago could, except by mere accident, show any pretence to good results,—so far, at least, as his knowledge extended. In fact, it was only within the last three or four years that the conditions had been appreciated; and the instance which Mr. Preece had detailed, in the paper which he had read, was the first instance in which anything like scientific care had been used. No doubt the causes of failure partly had been visible external carelessness, such as the mischief done by nails and by the reckless putting together of the materials, but the great and prominent reason which had governed every instance had been utter ignorance of the conditions necessary for a perfect union. It was only by the observance of such conditions that there would be any hope of attaining success. If the experience derived from the underground cable, which Mr. Preece had alluded to, was as satisfactory in the future as it was in the present, the care taken would be justified by the result. Of course two years', or a little more than two years' experience (for that was the period from the completion of the line), did not warrant their saying much; but at the same time it warranted their saying that no underground line that had ever yet been made had, after the lapse of the same period, shown anything like the same high tests. Mr. Preece had given the tests which presented themselves after the completion of the work. He (Mr. Graves) would merely say that, with the exception of one experimental length that was laid down under special conditions, and which did not affect the general bearing of the work, although a certain depreciation took place within the first six months, still during the last eighteen months there had scarcely been any change whatever in the condition of the cable; and the line now stood very much higher than any similar work with which he had any acquaintance throughout the kingdom.

Mr. R. von Fischer Truenfeld said that it might be interesting to make a few remarks with regard to the very earliest history of underground telegraph wires. The first underground wire was laid as early as 1842, by Professor Jacobi, in St. Petersburg, Russia. That was a copper wire in glass tubes. In 1845 came the first gutta-percha from India to Europe; and Dr. Werner Siemens made a series of experiments with gutta-percha with the view to use the new dielectric material for galvano-plastic purposes. In 1846, the learned doctor used for the first time gutta-percha for covering telegraph wires, and used such insulated wires for underground telegraph lines. After this first experiment had established the satisfactory result of good insulated wires, the Prussian Government telegraph administration decided, in 1847, to have this new system of underground wires introduced on an extensive scale; and they, in fact, laid about 1200 miles of gutta-percha underground telegraph wires which Dr. Siemens, in connection with the two well-known india-rubber manufacturers, Messrs. Fonrobert and Bruckner, then manufactured at Berlin. Although the Prussian telegraph administration was at that time, and he firmly believed was still, of opinion that underground wires were the most recommendable for telegraph lines, nevertheless the extensive experiments of 1847 turned out to be a failure. The reasons for this were obvious. The system was sound and recommendable, but the knowledge how to manufacture gutta-percha covered wires so as to possess the required insulation, and all the mechanical qualities of a good cable core, was at that time (the very infancy of cable manufacturing) by far too incomplete. The Prussian underground telegraph lines failed because they did not, and they could not, insulate. But they had one immense and valuable effect, namely, to be the first and most important step of our present submarine telegraphy. They introduced gutta-percha as an insulating material, and furnished very valuable results with regard to its use and manufacture.

The Chairman announced that the discussion would be adjourned until the next meeting.

A special meeting was then held for the revision of the rules and regulations of the society.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

October 7th.—Edward Schunck, F.R.S., vice-president, in the chair. W. Boyd Dawkins, F.R.S., exhibited a fragment of a post struck by lightning on June 2nd, 1873. It was completely shattered, fragments being driven as far as the walls of the house, twenty-five yards off, and the downward direction of the loose splinters implied that the explosive force was exerted from below upwards, instead of from above downwards. Mr. Baxendell though it was most probably due to the sudden conversion of a portion of the moisture in the post into steam of high tension by the heating action of the electrical discharge, and mentioned instances in which condensed vapour was said to have been seen rising from trees immediately after they had been struck by lightning.

Notices of Books.

The Galvanometer and its Uses. A Manual for Electricians and Students. By C. H. Haskins. New York: D. Van Nostrand. 1873.

Not long since, we saw in a leading American journal an answer to the recognition by Englishmen of American progress in telegraphy—particularly a reply to some eulogistic remarks by Mr. W. H. Preece in this journal upon Mr. Stearn's duplex system. English journalism would be very unfair to American versatility in invention if due recognition were not made in time and season. And equally unfair would it be not to recognise the practical worth of many American text-books. We should be unfair did we not particularly praise the little work before us. A synopsis of galvanometric formulæ, it embodies, in pocket-book form, the data most commonly required by electricians on active duty; and these data are further supplemented by efficient tables, diagrams of connections, &c. Starting upon the principle of "honour to whom honour is due," Mr. Haskins, where he has borrowed, carefully names the source; and he can afford to do this, for to those acquainted with American scientific literature

Mr. Haskins's name is too well known to need false buttresses. We append from the work an abstract upon "The Speed of the Current":—Many experiments have been made to determine the speed of transmission of the electric current or influence through a wire. The first measurement made by Wheatstone in 1833, showing a speed of 288,000 miles per second, was taken as the speed of the current under all circumstances. Subsequent measurements, however, showed such variable results, that confidence in Wheatstone's figures was much shaken. [Mr. Haskins then gives in tabulated form the various observed values; they have already been recorded in this journal.] The table gives, he continues, no data from which to make any calculation or deduce any law. It only serves to show how varied were the results obtained. To be of any benefit, the experimenters should have given the conductivity per mile of the wire used, the form of battery, and the number of cells used in each case. The English, French, and German experiments use, also, miles of different lengths. Thus, for land lines, we were without any reliable data until 1869, when Prof. G. W. Hough, of Dudley Observatory, and Mr. C. S. Jones, of Albany, New York, undertook a series of experiments to determine the velocity of the current. Mr. Jones, manager of the Western Union Office, by looping wires to Boston, Detroit, New York, and Buffalo, obtained circuits of sufficient length to test the question thoroughly. As Grove's battery was used, and the line-wire was galvanised No. 9, we have some data from which to draw satisfactory conclusions. On the 27th of May, Messrs. Hough and Jones obtained the following results:—

Velocity per second.	No. cells of battery.	Length of circuit.
10,200 miles.	70	400 miles.
20,000 ,,	160	400 ,,
29,450 ,,	295	400 ,,
18,200 ,,	295	1000 ,,

Professor Hough remarks, in relation to the above results:—"An inspection of these results show at a glance that the velocity increases with the number of battery elements employed; also, for the same battery it decreases with the length of the circuit." From these figures we deduce these facts:—First, that with a given resistance, the speed increases with the increase of electromotive force, *i.e.*, the power to overcome resistance and urge the current forward; second, that with a given battery, the speed of the current varies as the resistance to be overcome in the circuit varies. And these facts explain why Wheatstone obtained a velocity of 288,000 miles per second, when Hough and Jones show less than 30,000 miles as their greatest velocity. Wheatstone used a Leyden jar, discharging a current therefrom of the highest tension, and having but half a mile of resistance of circuit, while the Albany experiments were made through long circuits with battery currents of comparatively very low tension.

Elementary Treatise on Physics, Experimental and Applied, for the Use of Colleges and Schools. Translated and Edited from Ganot's "Eléments de Physique." By E. Atkinson, Ph.D., F.C.S., Professor of Experimental Science, Staff College, Sandhurst. Sixth edition, revised and enlarged. Illustrated by 4 coloured plates and 746 woodcuts. London: Longmans, Green, and Co. 1873.

The first English translation of Professor Ganot's "Eléments de Physique" was published in 1863, and so popular had the work been in France that the translation was from the ninth edition. The book has now become as popular in England, and deservedly so, for not only is the English clear and vigorous, but Dr. Atkinson has been careful to include in each edition the latest discoveries; and giving as it does the framework of the whole of the physical sciences, it is a trustworthy text-book for students. The headings of the books will show the range of subjects which the treatise embraces. They are as follows:—I. Matter, Force, and Motion; II. Gravitation and Molecular Attraction; III. Liquids; IV. Gases; V. Acoustics; VI. Heat; VII. Light; VIII. Magnetism; IX. Frictional Electricity; X. Dynamical Electricity; and Elementary Outlines of Meteorology and Climatology. The fact of the work consisting of only 840 pages shows that each subject is necessarily condensed. We should like to have seen a larger portion of the book devoted to electricity and telegraphy; but into the few pages devoted to this subject the translator has condensed a considerable amount of information, and has included the most recent applications. The description of Gramme's machine is accompanied with some good illustrations. We cordially recommend this work to our students.

A Treatise of Medical Electricity, Theoretical and Practical; and its Use in the Treatment of Paralysis, Neuralgia, and other Diseases. By Julius Althaus, M.D., M.R.C.P., London. Third Edition, enlarged and revised, with 147 illustrations. London: Longmans, Green, and Co. 1873.

We are glad to see a third edition of Dr. Althaus's admirable treatise. Not many years ago it was customary for the medical profession to pooh-pooh the idea of electricity curing disease, but that time has, happily, passed away; and it is a rarity to find a physician who does not believe in the value of electricity as a therapeutic agent. Dr. Althaus has greatly enhanced the value of this work by incorporating the most recent discoveries, and so rapid are the strides of this branch of science, that with each edition his task becomes more difficult. The chapters in the present edition are as follows:—Chapter I. Forms of Electricity; II. Electro-Physiology; III. Medical Electric Apparatus, and methods of using it; IV. Electricity as a means of Diagnosis; V. Electro-Therapeutics. Each of these chapters are subdivided, and embrace every branch of the subject. The illustrations are numerous, and well executed. We shall return to this work as soon as our space will permit.

Condoling by Electricity.—On the recent occasion of the death of Mr. C. L. Goodwin, superintendent of the Northern New York division of the Atlantic and Pacific Telegraph Company, the various operators of the division united in a meeting of condolence in the following remarkable manner:—All the stations included in that division were connected into one circuit, extending from New York to Albany, thence *via* Troy to Saratoga and return to Albany, westward to Syracuse, and *via* Oswego, Clyde, and Rochester to Buffalo and Niagara Falls, back from Buffalo *via* Auburn, Seneca Falls, &c., to Auburn again, being over twelve hundred miles of wire. Each person remained in his own office, and all the instruments were so connected that the remarks made by one operator upon his instrument were sent through all the other instruments. Promptly at 2 p.m. (Buffalo time) New York called the meeting to order. Buffalo moved that Mr. Hauff, chief operator at New York, be made permanent chairman. The motion was seconded by Troy, and carried. The chairman then suggested that Mr. McCoy, manager of the Buffalo office, be nominated as secretary, which the meeting unanimously resolved in the affirmative. Various speeches were made, and the resolutions were then read and adopted, and an adjournment then followed. The meeting was entirely harmonious through out, and the state of the weather and condition of th wires peculiarly favourable to its success.—*Scientific American.*

Correspondence.

MELOGRAPH.

To the Editor of the Telegraphic Journal.

SIR,—I read in your issue of the 15th Sept., page 273, a summary notice, without the author's name, of an apparatus called a melograph, exhibited at the Vienna Exhibition, and by means of which musical impromptu compositions can be electrically recorded. I contrived, in 1859, an apparatus of this kind, which has been described, with figures, in my "Exposé des Applications de L'Electricité" (second edition), vol. iii., page 117. It was exactly similar to the one you mention, and was the first apparatus of the kind invented.—I am, &c.,

TH. DU MONCEL.

THE ALLEGED DISCOVERY IN THE SCIENCE OF ELECTRICITY.

To the Editor of the Telegraphic Journal.

SIR,—The writer of the article under the above heading, in your issue of the 15th instant (in endeavouring to refute the statement that all the electricity liberated by a given battery, and passing through a "Decomposing Cell," is utilised in producing a given quantity of gas) seems to draw erroneous conclusions from his experiments. If the current had been passed *consecutively* through the "Decomposing Cells," the quantity of gas liberated in each cell, when both were in circuit, would no doubt have been (approximately) one-half the quantity produced when one cell only was in circuit—but it would appear that the internal resistance of the battery was small when compared with that of the "Decomposing Cell." So small, indeed, that it may be neglected—in that case, the internal resistance of A being evidently the same as that of B, the resistance of the entire circuit with A alone would be (approximately) double that of the entire circuit with A and B connected as described—

$$\left(\frac{A^R\ B^R}{A^R + B^R}\right)$$

Therefore, according to Ohm's law, the total quantity of gas generated would be doubled in the second case, and being equally divided betwwen A and B, would produce in each (approximately) the same quantity of gas, in the same time as when A alone was in circuit.—I am, &c.,

A. EDEN,
Government Telegraphs.

Edinburgh, Nov. 18th, 1873.

To the Editor of the Telegraphic Journal.

SIR,—I beg to draw your attention to the paper in your last issue by Mr. Casselberry, of St. Louis, North America, and to observe that the discovery there described was made and acted upon years past in this country. The experiment is suggested in Clark's "Electrical Measurement," page 38, published in 1868, and the principle involved is at the base of many telegraphic systems now in operation.—I am, &c.,

R. OFFORD.

13, Great Titchfield St., W.
November 22, 1873.

To the Editor of the Telegraphic Journal.

SIR,—With reference to a communication in your issue of November 15, from Mr. Evans Casselberry, entitled "A Discovery in the Science of Electricity," it would have been interesting if your correspondent had stated what were the relative resistances of his voltameters and battery—what number and description of cells did he use, and to what extent did local action interfere with the results obtained, in ascertaining the quantity of zinc consumed?

Without this information, the simple explanation of the phenomenon which suggests itself is, that the resistance of each decomposing cell was so great, as compared with that of the battery, that the practical effects of joining up two in duplicate arc was to halve the resistance of the original circuit, of course doubling the current and likewise the quantity of gas evolved.

Local action would account for the results with the zinc elements.—I am, &c.,

J. GAVEY.

Post-Office, Bristol, November 25, 1873.

THE MANUFACTURE OF ELECTRICAL INSTRUMENTS.

To the Editor of the Telegraphic Journal.

SIR,—Whilst allowing full credit for the exactness of the adjustment and excellent workmanship expended by instrument makers upon electrical measuring apparatus, which telegraph engineers have to use, it nevertheless is necessary to point out that much better constructions might be introduced. If designers and manufacturers of testing apparatus had opportunities of applying the apparatus themselves, they would improve many details.

Some months ago tests had to be made of a cable miles from any large town, on a beach of loose sand exposed night and day to the full force of the trade winds. Inside the hut, which was in a perpetual state of vibration, tests with mirror galvanometer or the suspended needle were impossible, and an expedition had therefore to be made to the other end of the cable to find a still hut where reliable observation could be made. Had the testing apparatus been so constructed as to be entirely independent of the cable hut, this second journey would have been saved. But darkness was necessary for the mirror readings, and darkness was only to be had in the hut, the floor of which vibrated. Now such an accident suggested that the resistance apparatus might have been put neatly into a box. The galvanometer with its lamp and scale, if such was at all necessary, might they not have been shut up in a box, with a peep-hole and telescope to observe by, and set up in a portable tripod, stuck in the sand in some corner, so as to be independent of cable hut and trade winds? This is an isolated case, but it seems to me, generally, that testing instruments are constructed only for the physical laboratory, where every condition is favourable and successive.

Great improvement might be effected in the general arrangement of the details of apparatus, and the only plan is either to carry the manufacturing body away in cable ship to distant station, or for a diligent committee of engineers to examine the working electricians who have had to use the different testing apparatus at present in use.—I am, yours, &c.,

ENGINEER.

THE ROYAL SOCIETY has awarded the Copley Medal to Professor Helmholtz, the distinguished physiologist, physicist, and mathematician, of Berlin; a Royal Medal to H. E. Roscoe, F.R.S., Professor of Chemistry in Owens College, Manchester; and a Royal Medal to Dr. Allmann, Professor of Biology in the University of Edinburgh.

MR. STEARNS'S duplex system is working successfully between London and Dublin, a distance of 400 miles, 70 of which are cable, and 6 underground. The work is effected without relays. The system is also in successful operation between St. Petersburg and Moscow, in Russia.

THE telegraph ship, *Africa*, after laying the 850 miles of cable between Alexandria and Brindisi, will proceed to lay a cable across the Straits of Messina.

City and Commercial Notes.

Messrs. Grant Brothers, the London agents of the River Plate and Brazil Telegraph Company (Companhia Telegraphica Platino-Brazileira) have intimated that the Government of Brazil has extended the period of the concession of the cable from 40 years, at which it was originally fixed, to 60 years; also that the manufacture of the cable is progressing very satisfactorily, and that vessels are now being fitted up for embarking it, so that the completion of the undertaking may be looked for at an early date.

The *Times* announces that news has been received of the total loss, near her station on the coast of Newfoundland, of the *Robert Lowe*, repairing ship of the Anglo-American Telegraph Company. The vessel is entirely insured, but it is feared that the captain and crew of 17 men have been drowned.

The Directors of the Globe Telegraph and Trust Company have resolved not to entertain at present any further applications for the exchange of shares.

The Oriental Telegram Agency announce a revised and reduced tariff for messages to Australia, China, India, &c.

Reuter's Telegram Company, Limited, announce a reduction in their tariff for the transmission of private telegrams to India on the word system.

The Eastern Telegraph Company's direct cable between Cornwall and Lisbon has been repaired, and is re-opened for traffic.

The directors of Hooper's Telegraph Works have received a telegram that the *Hooper* cable ship arrived at Madeira on the 17th inst., and would leave on the following day with the second section of cable to be laid between Pernambuco and Rio de Janeiro.

The Eastern Extension Company's Cable between Singapore and Penang is temporarily interrupted. The outward messages which have accumulated at Penang will be forwarded to Singapore by steamer, which probably leaves to-morrow, the 22nd inst. The fault, being close to Singapore, is expected to be speedily repaired. The charges for telegraphing to India by the Eastern Company's lines were greatly reduced on the 15th inst. The present tariff will be seen on referring to our almanack.

At the meeting of the West India and Panama Telegraph Company, Limited, held on the 17th ult., an important discussion took place. A Committee was appointed, on the motion of Mr. W. Abbott, which will report to a future meeting. The Committee are also empowered to take legal opinion as to whether the dividends on the Preference Shares are cumulative; this question was referred to the Committee because, in answer to a question, the Chairman (Sir J. C. D. Hay, Bart., M.P.) stated that they are not cumulative.

The list of the Indo-European Telegraph Company, issued on the 20th ult., shows an average time taken in transit, between London and Calcutta, of 1 hour 21 mins.; Bombay, of 1 hour 34 mins.; other places in India, of 2 hours 8 mins.

San Diego is now reached by telegraph.

We have received the following letter from the Secretary to the India-Rubber Telegraph Works Company relative to the cable between Colon and Jamaica:—

To the Editor of the Telegraphic Journal.

SIR,—With regard to the telegraph cable between Colon and Jamaica, now open for the transmission of messages, I beg to inform you that telegrams for and from South America may be sent without the addition of the words "care Nunes" hitherto requisite.—I am, &c.,

WILLIAM J. TYLER (*Sec.*).

305, Cannon Street, London,
November 21st, 1873.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Nov. 28.
Stock	Anglo-American (Limited)	100	86—87½
10	Brazilian Submarine..	9	2½—2¾ dis.
10	Cuba	All	8½—8¾
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	14	6—5 dis.
10	Eastern (Limited)	All	8¼—8½
10	Ditto New	All	..—..
10	Eastern Extn. Australia and China	All	8½—8¾
10	Great Northern	All	9—10
25	Indo-European	All	15½—16½
10	Mediterranean Extension (Limited)	All	4¾—5
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	3½—2¾ dis.
8	Reuter's..	All	10½—11½
Stock	Submarine	100	235—245
1	Do., Scrip	All	2½—2¾
10	West India and Panama	All	4¾—4¾
10	Do., 10 per cent Pref.	All	8½—9
20	Western and Brazilian (Limited) ..	All	12—13
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	88—92
10	Hooper's Telegraph Works	All	12½—12⅝
50	India-Rubber and Gutta Percha ..	All	27—29
Cert.	Submarine Cables Trust	100	109—112
12	Telegraph Construction	All	30—31
100	Ditto Ditto 7 per cent Bonds	All	102—105

Patents.

543. J. Vinault, of Melun, department of the Seine et Marne, and C. N. Bernier, of the department of the Loire, both in the Republic of France. *An Electric Detonating Disc and other Signals for preventing Railway Accidents, applicable to Railways.* Dated February 13, 1873.—This invention relates to a series of signals all worked by means of a rail placed in the middle of the way between the two ordinary rails, and lowered by a wheel carried by the locomotive. This centre rail is raised about six inches above the level of the ordinary rails, and attached to it are two racks gearing with a pinion enclosed in a box sunk between the rails; the axle of this pinion passes to another box placed outside the way, and by a toothed wheel at that end actuates another pinion upon a vertical shaft enclosed within a column and carrying at the top a disc, red on one side and white on the other. One of these signalling apparatus is placed at each approach to a station, the two being in connection, and working so that when a train runs into a station the signals cover the line both before and behind it. At the same time the chains passing over a pulley on each vertical shaft and connected by an iron wire which connects the two discs, also cause an electric bell to sound until the discs are reversed and the line open. These chains are also connected by a lever with a bellows provided with a horn which is thus made to sound at points or level crossings. The racks also act upon a lever which places a detonating signal on the line to be exploded by the passing locomotive, finally to signal the falling in of a bridge or its being carried away by flood; the wire connecting the two signalling discs is passed between the cutters of a shears kept open by a spring between its two handles or levers, one of these being connected by a chain with the arch of the bridge, so that should this arch give way the cutters close, cut the wire, and sets the discs of each column at danger.

594. J. H. Lee, of the Naval and Military Club, St. James's, Middlesex, Lieutenant in Her Majesty's Royal Navy, and C. Pringle, of Surrey, Captain in Her Majesty's Royal Navy. *Preventing the Destruction of Boilers and Engines by Galvanic Action.* Dated February 18, 1873. The introduction of zinc into boilers, engines, and such like when fitted with fittings containing copper, and thereby diverting the galvanic action.

618. H. Wilde, of Manchester, Lancaster, *Improvements in Machinery and Apparatus for Producing,*

Regulating, and Directing Electric Light, part of which is Applicable to other Purposes. Dated February 19, 1873. My invention consists, firstly, in improvements in the electro-magnetic induction machine, described in the specification of No. 842 (1867). In the present improvement the helices in which the currents are induced, instead of being coiled round the armatures, are coiled round the extremities of the iron cores of the electro-magnets, which are prolonged for that purpose, or have iron cores fixed thereto, and an iron wheel or disc, the periphery of which is divided into as many segments as there are electro-magnets in each circle, is made to revolve between the circles of stationary electro-magnets and coils for the purpose of generating electric currents. My invention consists, secondly, in improvements in the apparatus for regulating the approach of the carbons used for producing the electric light as they are consumed by the current. In this improvement the carbons are made to approach and to separate from each other by means of a right and left handed screw, connected with the carbon holders. Each of the screws, with its carbon holder, can be actuated independently of the other. My invention consists, thirdly, in apparatus for directing and projecting the electric light upon distant objects. In this improvement the light is condensed into a single beam by means of a holophote, or a parabolic reflector mounted on a platform, on which is also placed the regulator above described. The whole apparatus retains whatever position is given to it both horizontally and vertically without the use of any locking movement.

625. F. Sanders, of Birmingham, Warwick. A communication from Richard David Sanders, of Bombay. *Improvements in Communicating or Signalling on Railway Trains, and in Warming Railway Carriages.* Dated February 19, 1873. According to this invention for the purpose of communicating or signalling on railway trains, a receiver containing condensed air is fixed under the tender of the engine, the condensing air pump of which is worked by the engine or by hand. In communication with this receiver is a hollow cylinder, having within it a disc or piston smaller than the cylinder. A rod from the disc passes through the cylinder, and is connected to the lever of a steam whistle or other alarm. The top of the hollow cylinder is in communication with a pipe running under the carriages, branch pipes therefrom passing to the compartments of the carriages, and being furnished with stopcocks. When the apparatus is in its normal condition the disc or piston in the cylinder is balanced; but if by accident the train is divided and the pipe under the carriages is ruptured, there is a free passage of the condensed air from the ruptured pipe. The pressure of the air in the receiver being no longer counterbalanced, the said air rushes through the cylinder and raises the disc therein, which opens the stopcock of the steam whistle or alarm, and the said whistle or alarm is brought into action. The same operation takes place when a passenger opens one of the stopcocks in the carriages. In the latter case the compartment from which the signal is made is indicated by a flag, which is blown by the escaping air from a tube passing out laterally from the carriage. To adapt this invention to the warming of railway carriages, the condensed air is passed through a coil of pipes in the smoke-box of the engine, and the pipe under the carriages is connected with shallow boxes which form a portion of the floor of the carriages and act as foot-warmers, the heat arising from them also warming the carriages.

686. F. J. Bolton, of Westminster, a Major in the Army, and C. E. Webber, of Kensington, a Major of the Royal Engineers. *An Improved Method of Obtaining Photometric Measurements, and Apparatus for that Purpose.* Dated February 24, 1873.—This invention relates to a method of and apparatus for obtaining photometric measurements in terms of electrical measurement. A body, of which the electrical conductivity or resistance is altered by exposure to light is placed in an electrical circuit, in which circuit is also placed an electrometer or guage of electrical resistance. Light is directed on the body, and the value of this light, or the transparency or density of any translucent substance through which the light is passed is tested by the effect on the electrometer or resistance guage.

706. A. V. Newton, of Chancery Lane, Middlesex. A communication from C. F. Mildé and L. C. Vimard, both of Paris, France. *Improvements in Electric Clocks.* Dated February 25, 1873.—This invention relates to a novel arrangement of apparatus for applying electricity as the motive power to the working of clocks, and more particularly those clocks used on board ship.

735. T. A. Edison, of Newark, New Jersey, U. S. A. *Improvements in Circuits and Instruments for Chemical Telegraphs.* Dated February 27, 1873.—This invention is to increase speed on long chemical telegraph lines and render the marks clear and distinct. The counter current set up in an electro-magnet as it discharges itself upon breaking the circuit is employed in a shunt or branch to neutralise tailings. Two or more stylus or pens in main line with shunt circuit and magnet in each are also used. Drop copies are taken by a division or branch and the magnet and receiving instrument or a vessel of water into which the circuit wires are introduced. With a very rapid circuit breaker and resistance in the main line, the transmitting instrument is placed in a circuit connecting at both sides of the resistance. An induction coil is employed as a relay for the automatic transmitting system, the same sending a secondary current to the receiving instrument or to another induction relay. Reaction batteries are introduced upon the line or in branch or shunt circuits, to clear the line of surplus electricity, the power of the same being much less than that of the main battery, and the poles opposed.

761. G. K. Winter, F.R.A.S., telegraph engineer of the Madras Railway of Arconum, Madras, British India, at present residing at Shepherd's Bush, Middlesex. *Improvements in Electric Telegraphs.* Dated March 1, 1873.—The objects of this invention are the improvement of duplex telegraphy and its application to submarine cables.

785. W. C. Barney, of Lombard Street, London. *Improvements in Electric Telegraphs.* Dated March 4, 1873.

861. W. C. Barney, of Lombard Street, London. *Improvements in Electric Telegraphs.* Dated March 10, 1873.

UNITED STATES.

141,076. George M. Phelps, Brooklyn, N.Y. *Printing Telegraph.* Dated December 17, 1872.

141,352. John C. Hinchman, Summit, N. J. *Electro-Magnetic Date Time Printer and Stamp.* Dated February 24, 1873. A timepiece, provided with minute, hour, and calendar wheels, having raised figures and letters on their edges, arranged in line side by side, and operated from the timepiece by a pawl and armature lever of a magnet, is combined with a suitable inking and spring plate device, so that the time and date may be at any time printed, either by a hand pad or by the action of a second electro-magnet.

ERRATUM.—In No. 11, vol. i., page 200, "Mance's Method for Determining the Resistance of Batteries and Galvanometers," foot of second column, read "if we make the resistance (R) *small*, we shall have a larger deflection when K is open than when pressed down, but if R is GREAT, then when K is pressed down," &c.